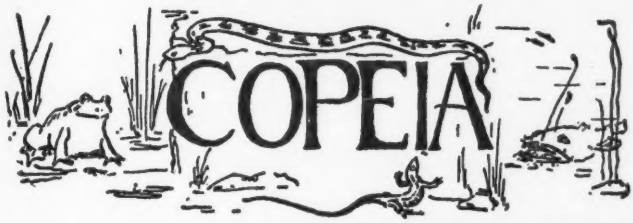
CHICAGO, FEBRUARY 1, 1923, No. 115



Published to advance the Science of cold-blooded vertebrates

Abstract of the Proceedings of the Seventh Annual Meeting of the American Society of Ichthyologists and Herpetologists

HELD IN CHICAGO, OCTOBER 27, 1922, AT THE FIELD MUSEUM OF NATURAL HISTORY

The seventh stated annual meeting of the American Society of Ichthyologists and Herpetologists was held in the Field Museum of Natural History, Chicago, October 27, 1922. The business meeting came to order at 9:30 A. M. Present: Dunn, Nichols, Ruthven (by proxy—Mr. C. W. Creaser), Schmidt, Wright, and later Weed.

An abstract of the minutes of the previous meeting was read and approved.

The following officers were elected: President, Stejneger; Vice-presidents, Barbour and Wright; Treasurer, Fowler; Secretary, Nichols.

The following candidates were unanimously elected to membership after discussion of the individual merits of each:

Mr. H. P. Löding
Professor H. H. Lane
Miss Sarah Rogers Atsatt
Mr. Ernest W. Brown
Mr. Will H. Dilg
Professor G. C. Embody
Mr. Thomas Hallinan
Mr. F. S. Young
Mr. L. L. Walters
Mr. L. L. Pray
Hon. George N. Mannfeld
Professor R. V. Truitt
Mr. George Finlay Simmons
Mr. Percy Viosca, Jr.
Mr. Alvin R. Cahn
Mr. Remington Kellogg
Dr. Thomas H. Macbride

It was voted to meet in Cambridge in 1923, with Vice-president Barbour chairman of the Arrangements Committee for that meeting, said committee to determine the date of meeting. The Secretary called attention to the fact that the Philadelphia meetings of 1917 and 1921 had elected to meet with the American Ornithologists Union in the fall of 1918 and 1922, the other five meetings having been held independently in the spring.

It was voted that the Local Committee of this Chicago meeting issue an abstract number of Copeia, in consultation with the Treasurer according to custom.

Payment of bills incurred by the local committee in connection with the present meeting amounting to $31.50 was authorized.

The business meeting then adjourned and the public session convened for the reading of papers with Vice-president Wright in the chair. Twenty persons attended this session, including C. H. Eigenmann, T. L. Hankinson, W. L. McAtee, N. E. Pearson, Percy Viosca, Jr., L. L. Walters, R. V. Truitt, C. W. Creaser, George N. Wagner, L. L. Pray, C. C. Sanborn, George Finlay Simmons, and F. S. Young.

Papers by Dunn, Eigenmann, Hankinson, Nichols, N. E. Pearson, Pray, Schmidt, Simmons, Viosca, Weed and Wright were read and discussed and others by Thomas Barbour, Frank N. Blanchard, William K. Gregory, Thomas Hallinan, and Alexander G. Ruthven presented by title, before and after a short mid-day recess for an excellent luncheon in the Museum, which had been arranged by the local committee (Weed and Schmidt), and was courteously provided by the Chicago members of the Society.

The public sessions adjourned at 5 P. M. with a vote of thanks to the trustees and staff of the Field Museum of Natural History for the many courtesies received and of appreciation of the work of the Local Committee.

J. T. NICHOLS, *Secretary.*

OBSERVATIONS MADE IN DUVAL COUNTY, NORTHERN FLORIDA, ON THE GOPHER TORTOISE *(GOPHERUS POLYPHEMUS)*

THOMAS HALLINAN

(Read by Title)

GENERAL HABITS

In the Dinsmore locality during March, 1922, small sticks were placed across the entrances of eight burrows for fifteen evenings and in the mornings they were not disturbed, but they were moved sometimes during the day.

One specimen in captivity was always quiet and inactive during the night but restless soon after dawn and at times uttered a low, piteous cry.

If the tortoise is within the burrow it will make a low-toned noise like air escaping under pressure, if the sand at the entrance is slapped with the palm of the hand, and by listening closely the Tortoise can be heard moving about.

During the week ending April 15, 1922, in the Dinsmore locality a small tortoise (4 by 4¾ inches) was seen at 12:30 P. M. resting in the sun about 12 feet from the mouth of its burrow and when disturbed made a frantic effort to enter. The same specimen was observed on two other days at about noon in the entrance of the burrow, about two feet down. Another specimen about the same size in another burrow was seen about noon resting in the entrance, about two feet down and on another day about noon was seen resting in the sun just outside of the entrance. On April 16, 1922, in the Cedar Creek locality, a specimen (5¾ by 7½ inches) was seen resting in the burrow about two feet down in the entrance. On June 11, 1922, in the Eastport locality, a specimen (8 by 10 inches) was seen walking along a trail in the pine woods a considerable distance from any burrows.

The Gopher hunters usually capture them by using a pole with a hook on the end, which they push beyond the tortoise in the burrow and hook onto its carapace. Where the holes are fairly straight, which is seldom, they can go to the bottom with this flexible pole and haul out their game. The bottom of the burrow appears to be their usual resting place.

Their flesh is considered a delicacy in this section and their eggs are in high favor with the epicures.

FOOD

Stomach examinations showed that the grasses were their regular diet.

One specimen from burrow No. 1 in the Cedar Creek locality taken January 29, 1922, had in her digestive tract a round ball, about two inches in diameter, made up of concentric layers of mixed sand and calcareous cement, which weighed about seven ounces.

At the bottom of the burrows from two to three inches of dung is usually found and this is made up principally of partly digested grasses.

HABITAT PREFERENCE

They are found in widely separated localities and the elevation and drainage of the land must be sufficient to keep the bottom of their burrows above the water level of the soil.

The pine lands where the trees are well separated with a sparse growth of scrub oak and grasses growing beneath are the favorite locations. The pine woods on the south bank of Cedar Creek where the elevation is about 20 to 30 feet above the water level is an ideal environment and here within a square mile several hundred burrows may be found. On the north bank of Cedar Creek is a closely wooded area of pines, bays, magnolias and other trees of size with a thick undergrowth beneath and here the burrows are only found in the open places in the woods.

Duval County is generally flat and but a few feet above sea level, which establishes a permanent water level in the soil very near the surface. In many places, however, there are plateaus from 20 to 50 feet above the sea level, and on Fort George Island an elevation of 63 feet is recorded, the highest point on the East Coast of Florida. The tortoises are found on these elevations when the proper food plants are present and when the vegetation is not too dense.

BURROWS

Figure one gives a typical distribution of their burrows. Sometimes they are more widely scattered and in some locations they are closer together. In one instance the entrances of two burrows were parallel and within four inches of each other.

Figure two shows the angles of declination of 12 burrows excavated in two localities.

FIGURE 1.

Distribution of 9 Gopher Tortoise burrows in the Cedar Creek locality in Duval County, Northern Florida. Excavated during January and February, 1922.

Scale one inch equals 100 feet.

From experience thru ages, the tortoises seem to have found that the most practicable angles for their burrows to enter the earth lie between 15 and 30 degrees. Within this range of angles the minimum effort is reached in burrowing to the required depth. In burrow No. 8 an angle of 45 degrees was attempted but the work was abandoned by the tortoise.

The depth of the burrow is determined by the moisture content in the soil. It appears that, altho they are wholly terrestial in their habits, they require a certain degree of humidity in the bottom of the burrow.

In excavating the burrows it was found they often dug into hard clay and among large pebbles of bog iron ore in the sand but the burrows always ended above the water level in the soil.

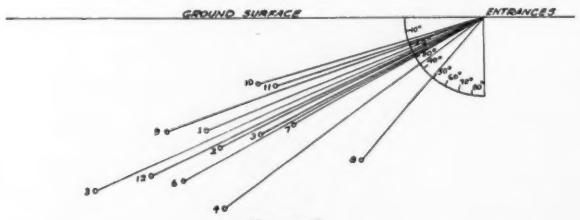


FIGURE 2.

Vertical view showing the angles of declination of 12 Gopher Tortoise burrows excavated in Duval County, Northern Florida during January, February, March and April, 1922.

Scale one-eighth inch equals one foot.

On a plateau about 50 feet above sea level on Fort George Island one burrow was partially excavated on May 28, 1922, and after excavating along this burrow for 24 feet and 11 feet vertical depth the bottom was not reached. The permanent water level was very deep in this locality. This burrow entered the earth thru about two feet of oyster shells. Fort George Island was thickly wooded except a number of small areas on which were great quantities of oyster shells, apparently brought there by the Indians from the nearby waters, where prolific oyster beds can still be found. The tortoise burrows were located only in these open areas. The entrances of the burrows must have the unobstructed rays of the sun to hatch the eggs which are laid in the sand in the opening.

Sometimes the entrances have no vegetation in their vicinity and

at other times they are located near clumps of shrubbery, under logs and under the creeping caudexes of the Palmetto *(Chamaerops hystrix),* but always in the open where the sun shines direct on the entrance some time during the day.

The burrows enter the ground from all points of the compass and their cross-section area depends on the size of the occupant, and apparently this is enlarged as the tortoise increases in size. The cross-section of the burrow takes the form of a segment of a circle and the width is about twice the height. The largest dimensions noted were about 11 inches wide and 6 inches high. The tortoises occupying burrows of this size have carapaces measuring about 7 to 8 inches wide and 10 to 12 inches long and this is about the normal size of the adult.

The length of the burrow is determined by the angle of declination and the element of moisture in the soil. Measurements of 19 occupied burrows averaged 14.6 feet in length with a maximum of 20 feet and a minimum of 10½ feet.

Figure 3 shows the horizontal plan of 12 burrows from two localities. The turns are determined by the roots and other obstructions encountered and they do not alter the length or the amount of material removed. In burrow No. 12 a large root was encountered just inside of the entrance and the tortoise made a cavity 24 by 28 inches and 5½ inches high and then changed the angle of declination slightly and burrowed below the root.

The material is apparently dug loose with the front feet and pushed out of the burrow with the carapace acting as a shovel-plow. From the small amount of sand at the entrances in comparison to the cubical contents of the burrows it is evident that a large amount is forced aside radially, as the sand is quite compressible. The sand is found to be well packed around the tunnels and this peripheral packing gives greater strength, especially during the heavy rains. In proportion, more sand is found at the entrances of the burrows of smaller tortoises than at the entrances of the larger ones, due no doubt to the lesser strength of the smaller which lessens the amount of sand that they can force aside radially. In burrow No. 12 the sand was flaky, dry, flour-like, and very compressible, with only about one cubic foot placed outside of the entrance, but the cubical contents of the burrow was 6 cubic feet showing that about 85% of the sand was forced aside radially and not removed from the burrow.

EGGS

In the ovaries of one Gopher Tortoise (7¼ by 9¼ inches) taken in burrow No. 1 in the Cedar Creek locality on January 29, 1922,

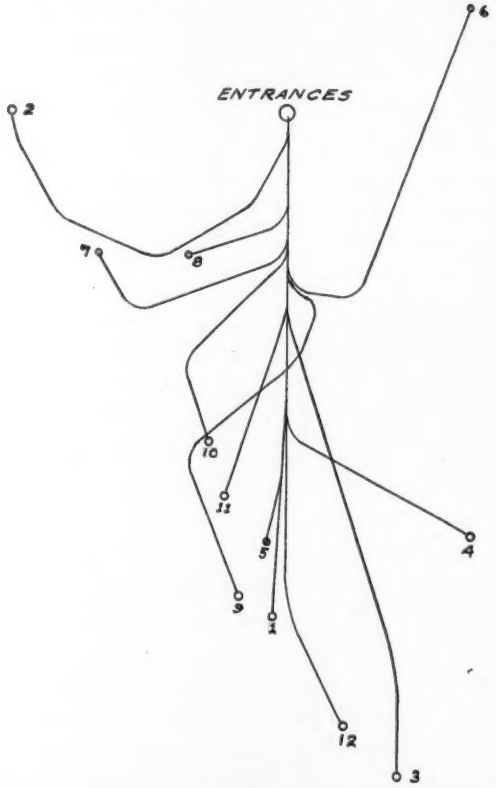


FIGURE 3.
Horizontal view showing the direction of 12 Gopher Tortoise burrows excavated in Duval County, Northern Florida during January, February, March and April, 1922.
Scale three-sixteenths inch equals one foot.

were found six spherical eggs, without shells, about ⅞ of an inch in diameter. In the ovaries of another specimen (8 by 11 inches) taken in burrow No. 10 in the Dinsmore locality on March 28, 1922, were found five spherical eggs, without shells, about one inch in diameter and two about ½ inch in diameter.

On the following dates in the following localities the sand was examined in the entrances of the burrows and no eggs were found:

Arlington, March 5, 1922; 9 entrances examined.

Cedar Creek, March 12, 1922; 56 entrances examined.

Cedar Creek, April 16, 1922; 42 entrances examined.

On Fort George Island on May 28, 1922, seven sets of eggs of the Gopher Tortoise were collected and in the New Berlin locality on June 4, 1922, two sets were collected.

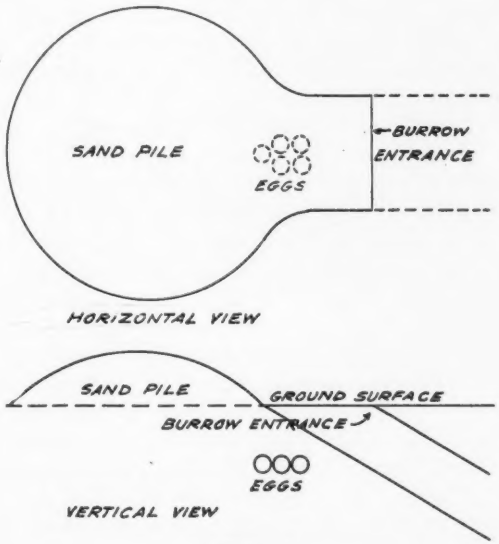


FIGURE 4.

Typical disposition of the eggs of the Gopher Tortoise at the entrance of their burrows, Duval County, Northern Florida in late May and early June, 1922.

Scale three-fourths inch equals one foot.

The eggs were white, nearly spherical in shape, freshly laid, and hard-shelled similar to a bird's egg. The average least diameter of 31 eggs from Fort George Island was 1.5 inches and the average greatest diameter was 1.6 inches. Some had a difference only of 3/100 of an inch between their greatest and least diameters. In the New Berlin locality the 11 eggs taken had an average in the least diameters of 1.57 inches and an average in the greatest diameters

of 1.74 inches. In one set the deviation from the usual spherical form was very marked—one egg had 3/10 and another 4/10 of an inch difference in the maximum and minimum diameters. The eggs numbered from 4 to 7, inclusive, in a set, while the average number of eggs in 9 sets was five.

They were deposited in the sand from 10½ to 18 inches distant from the burrow entrances with an average distance of about 13 inches. They were found from 4 to 8 inches deep in the sand with an average depth of about 5 inches, and were about ½ inch apart. They were laid on one level except set No. 7 where 4 of the eggs were on one level and the other 3 just above them. The center lines of the groups of eggs were in line with the center of the burrow entrances. Above the eggs the sand was soft where the parent had removed and replaced it after depositing the eggs. The eggs can be located by testing the sand with a small stick to determine the relative packed condition. The size of the eggs is usually in proportion to the size of the cross-section of the burrows.

In the Cedar Creek locality on May 31, 1922, the entrances of 44 burrows were examined but no eggs were discovered and this was due no doubt to this locality being on an elevation with only a sparse stand of Pines with little undergrowth, thru which the cool north winds had full play and perhaps retarded the egg laying, while on Fort George Island and in the New Berlin locality the burrows were protected with heavy timber and thick undergrowth.

All the eggs were found in burrows where the entrances had the benefit of the unrestricted rays of the sun for the greater part of the day.

ASSOCIATES

The following are the animals that were observed associated, directly or indirectly, with the Gopher Tortoises:

MAMMALS

Florida Skunk *(Mephitis elongata)*. When burrow No. 3 was excavated, one female skunk was taken from the bottom and it dug two feet beyond the end when it was disturbed. No tortoise was in the burrow at the time but a number of Diptera were found, probably associated with the skunk. About a peck of dry pine needles was in the bottom and this was the only burrow excavated in which pine needles were found. On July 19, 1922, in the Cedar

Creek locality a skunk was observed just before night fall within a few feet of a Gopher Tortoise burrow and the tracks of the skunk on the sand in the entrance indicated that the skunk had just come out as it had rained shortly before and the tracks were fresh. From appearance, it seems that the skunks inhabit the abandoned burrows. It was reported locally that the skunks and raccoons dig up and eat the tortoise eggs but this was not confirmed by observation.

Florida Gopher or Salamander *(Geomys tuza floridanus)*. Often make their numerous tunnels in the same localities where the Gopher Tortoise burrows are found but it was not observed in any instance that they communicated. The tunnels of the *Geomys* came within 18 inches of the Gopher Tortoise burrows No. 8 and No. 9 but did not connect.

Rabbits, opossums and raccoons are said to seek shelter in the burrows of the Gopher Tortoises when they are pursued but this was not confirmed by observations.

REPTILES

Black Racer *(Coluber constrictor)*. On April 16, 1922, in the Cedar Creek locality one was captured and after being released it glided about 30 yards and went into a Gopher Tortoise burrow. In the late afternoon on April 12, 1922, in the Dinsmore locality one Black Racer, 45 inches long, was captured and after being released went into a burrow and was seen next morning with its head sticking out.

It was extensively reported locally that the Diamond-Back Rattlesnake *(Crotalus adamanteus)* and the Gopher Snake *(Drymarchon corais couperi)* were often found in the burrows of the Gopher Tortoise but this report was not confirmed. While excavating burrow No. 3 a snake slough was found about 3 feet down in the entrance.

Race Runner *(Cnemidophorus sexlineatus)*. On April 16, 1922, in the Cedar Creek locality they were seen going in and out of the Gopher Tortoise burrows.

AMPHIBIANS

Gopher Frog *(Rana aesopus)*. One male specimen was taken from burrow No. 7 in the Cedar Creek locality on February 19, 1922. A Gopher Tortoise (7 by 5¼ inches) was also taken from this burrow at the same time. Two specimens were taken from

burrow No. 10 in the Dinsmore locality on March 26, 1922. They were observed on two days just before sunset, resting in the entrance about two feet down in the burrow and they were not seen at other times during the day. A Gopher Tortoise (11 by 8 inches) was taken from this burrow at the same time. One specimen was observed about sunset at the entrance of a burrow in the Brentwood locality on March 19, 1922. Two specimens were taken from burrow No. 11 in the Dinsmore locality on April 12, 1922. They were observed several times resting in the burrow about two feet down in the entrance just before sunset. A Gopher Tortoise (10 by 7¼ inches) was taken from this burrow at the same time. In the Dinsmore locality during the week of April 15, 1922, a pair of Gopher Frogs was observed on several days about sunset resting just inside of the entrance of a burrow. In the Cedar Creek locality on June 25, 1922, one specimen was seen at 1:30 P. M. resting in the grass about 5 feet outside of the entrance of a burrow and when disturbed made three hops and entered. The frog rested motionless for a short interval of time between the jumps but its actions were quick.

Gopher Frogs are not always found associated with the Gopher Tortoises as a Gopher Frog was taken in the Dinsmore locality on March 28, 1922, in about 6 inches of loose sand; another in about 8 inches of sand; and two specimens were taken in a hole about two inches in diameter under a dead stump.

Southern Toad *(Bufo terrestris)*. On Fort George Island several were collected while they were resting in the entrances of the Gopher Tortoise burrows during a rain on May 28, 1922.

INVERTEBRATES

Crickets. In nearly all the burrows excavated Crickets were found at or near the bottom.

Diptera. Several were found in burrow No. 3 from which a skunk was taken. Very often various species of Diptera and Hymenoptera were observed flying in and out of the burrows but their purpose was not determined.

Spiders. These were occasionally seen ranging in and around the burrows.

The collaboration of Mr. Sewel Wilford of Mayfield, Kentucky, and Mr. Harrold Smith of Jacksonville, Florida, aided greatly in maintaining a satisfactory sequence in these observations.

DISTRIBUTION OF THE PICKERELS

ALFRED C. WEED

The fishes of the genus *Esox* are divided into three well-marked groups. All are found in North America and each presents some special features of interest. The circumpolar range of *Esox lucius* offers a field for speculation as to the possible method of dissemination. The peculiarly restricted range of the Muskallonge, whether one, two or three species, needs explanation.

In a study of the distribution, variation, etc., of this group, which has occupied my attention for several years, most of the time has been spent on the group made up of the three nominal species *Esox tridecemlineatus, Esox vermiculatus* and *Esox americanus.* In large part, this has been because more material has been available than in the other groups. Especially in the case of the Muskallonge the dearth of material is marked. Most persons who catch a large fish want to eat it or else to have it mounted. In either case, it quickly loses all value as a scientific specimen. The case of *Esox lucius* is almost as bad, but the pickerels are so small that few eat them and hardly anyone ever has one mounted.

The Chain Pickerel, *Esox tridecemlineatus,* taken from the Finger Lakes of central New York, is easily recognized. The Trout Pickerel, *Esox americanus,* of Massachusetts, is easily distinguished from the Grass Pickerel, *Esox vermiculatus,* of Lake Ontario. With this idea of their distribution it was easy to separate the three species. Even when we found that specimens from Maryland were very similar to others from the upper Mississippi River, it was easy to say that the Trout Pickerel was separated from the Grass Pickerel by geographical distribution. One was confined to the Atlantic coastal plain and the other to the region west of the Appalachians. This was the view held until I began to study the specimens in the U. S. National Museum. There I found a continuous range from Maine to Florida, along the Gulf coast to the Mississippi and up that river about to St. Louis. Since the range of *Esox vermiculatus* was up the Great Lakes and in the headwaters of the Mississippi, the Ohio and the Illinois, and since the variation around this circuit seemed to be rather continuous, it was natural to suppose that the two connected in the St. Louis region.

It is not known whether there are pickerels found in all parts of the Ohio River basin or of the Wabash basin. The distribution from the south apparently extends up the Wabash to New Harmony, Indiana. Our present knowledge, however, indicates that there is a real break of about a hundred miles in the Mississippi valley. I have reports, which seem authentic, of Grass Pickerel in bottomland ponds as far north as Maeystown, Illinois, about opposite Crystal City and Festus, Missouri. They have been taken as far south as Quincy, Illinois, and Meredosia, Illinois. Between these points they seem quite unknown.

The peculiar distribution of these fish raises the question of their origin. When we thought there was continuous range of the species through the Mississippi valley it was easy to suppose that the group was driven south by the great ice sheet and then followed the glacier back as it retreated. We could then suppose that the pickerels entered the Great Lakes basin through the Illinois River. This would account for the fact that the great body of the pickerels south of the glaciated region is quite homogeneous in character and that there is continuous variation away from this central body both along the coast and down the Great Lakes. The fact that there seems to be some reason for believing that there is also variation away from this central mass in southern Florida and in southern Texas lends strength to this hypothesis.

Up to this point we have apparently a clear case and can be excused for trying to expand the theory to account for some other confusing points in the group. The break at St. Louis upsets all our calculations because conditions seem to be ideal for pickerels all through the region where they are absent. Of course, we can suppose that the entry to the Great Lakes came through some other channel, possibly the Ohio River. That would allow us to suppose that the fish are not found just north of St. Louis because they have not yet extended their range so far. That brings in the difficulty that they should, in that case, show considerable differences on the two sides of the break. Specimens from Moredock Lake should be very different from specimens taken at Quincy or Meredosia and these should be somewhat different from each other. Perhaps they are different. I have no specimens from these localities as yet. Some living specimens I have seen from Meredosia are very large and all the Missouri and Arkansas specimens are much smaller. Many more fish are needed to settle this point.

The third species in this group is *Esox tridecemlineatus,* the Chain Pickerel. This fish has a distribution practically within the range of *Esox americanus.* It is found alone in some lakes and streams of New York and New England. In other places the Trout Pickerel is found alone. It has been recently reported to me that the Chain Pickerel alone is the common form in the inland waters of New Brunswick. If this is true, then this form extends a little farther to the northeast. It does not extend quite as far up the Mississippi. If I am not mistaken, it does not extend north of central Arkansas.

In much of the coastal plain the habitat of *Esox americanus* is exactly the same as that of *Esox tridecemlineatus* and a very large amount of hybridization seems to occur. Indeed, a very large percentage of the specimens smaller than the largest *Esox americanus* are quite unidentifiable. Without making a careful study of the records I should guess that nearly half of the pickerels from the vicinity of Washington, D. C., are intermediate in one or more important characters. Further study is needed to show the relative value of this point. Perhaps it is simply an expression of extreme variation in a very variable group. Perhaps there is simply variation with age. It is not likely that the number of scales in the lateral line will change but there is a possibility that some of the "rudimentary" rays in dorsal and anal may increase in size and be counted in the larger fish. The only way to determine this point is to make a careful study of a long series of specimens of various ages from a restricted locality.

To make a satisfactory solution of the problem, many more specimens are needed. It is especially important to get material from the extreme points of the distribution of the group.

A CONTRIBUTION TO THE LIFE HISTORY OF *HEMIDACTYLIUM SCUTATUM* (SCHLEGEL)

FRANK N. BLANCHARD

(Read by Title, No Abstract)

A MIDDLE JURASSIC FISH FAUNA FROM WESTERN CUBA, WITH REMARKS ON THE ADAPTIVE RADIATION OF THE HOLOSTEAN GANOID FISHES

WILLIAM K. GREGORY

(Read by Title, No Abstract)

FISH MOUNTING FOR MUSEUM EXHIBITION

LEON L. PRAY

Until recent years, the mounting of fish for museum exhibition has been a neglected branch of taxidermy, chiefly on account of the difficulties to be surmounted.

Fish skins have been mounted in a great number of ways. Simple "stuffing" was probably the original method. Many variations in the method of handling the original fish skin have been hopefully conceived, only to be found wanting in practice. Among the mounted fish in the Field Museum of Natural History, are specimens with one side of the skin tacked on the edge of a board silhouette, the skin filled with damp sawdust and the head with plaster of Paris. There are fish skins drawn over hard wrapped excelsior bodies on board cores. This method is modified in later specimens by surfacing the excelsior body with clay or plaster. A novel method consisted in skinning the specimens, filling the skin with sand until dry, the sand being then removed through a hole on the "wall side" of the specimen, and a paper manikin pasted in.

A number of years ago, Mr. William Heim, while employed here under Curator of Zoology Charles B. Cory and Assistant Curator of Ichthyology Dr. Seth E. Meek, worked out a means of overcoming most of the shrinkage and warpage in mounting fish specimens by making plaster molds of the fresh fish, then skinning the fish and after carefully replacing the skins in the moulds, filling them with plaster of Paris, with an excelsior core in the center of each. Up to that time, this was the best step that had been taken in fish mounting. But the head details still shrank and scales curled and the specimens were undesirably heavy.

For several years I had an idea that has been brought to a practical conclusion under the direction of Dr. Wilfred H. Osgood, Curator of Zoology, and Mr. Alfred C. Weed, Assistant Curator, Division of Ichthyology in the Field Museum, in the past three years. This idea embodied the preparation of fish specimens by means of casting the bodies in plaster of Paris and using the natural fins upon the cast bodies. The method has proven so satisfactory, along with my fish-scale-pearl system of coloring the specimens, that I deem it worth passing on for the consideration of other Museum

Preparators who realize the limitations that beset their production of good fish specimens by mounting the skins.

A detailed account of this method of preparing exhibition specimens of fish is in preparation, and will be published as a technical bulletin by the Field Museum of Natural History.

THE BREEDING HABITS OF SALAMANDERS AND THEIR BEARING ON PHYLOGENY

E. R. DUNN

In a recent paper (Dunn 1922) I have proposed an arrangement of the Caudata which aligns them in two superfamilies, the Cryptobranchoidea (containing the families Hynobiidae and Cryptobranchidae), and the Salamandroidea (containing the families Ambystomidae, Salamandridae, and Plethodontidae), and leaves as forms whose relationships are uncertain the three families Amphiumidae, Proteidae, and Sirenidae. The three last named are marked by more or less complete neoteny or retained larval characteristics, and two of them have also developed extreme snakelike body form, with loss or reduction of limbs.

It is interesting to examine the breeding habits in order to see whether or not there is any agreement with the classification just proposed; to ascertain, if possible, the primitive habits; and to seek a possible clue, in the habits, to the relationships of the three degenerate groups.

Repeated observations on many forms assure us that the method of fertilization in the Salamandroidea is essentially uniform. Females of this group have seminal receptacles, or spermathecae, the males have a complex system of glands which open into the cloaca by papillae, and form the spermatophores by whose means internal fertilization is accomplished. It should be noted that this method of fertilization is here dependent upon a peculiar and well developed set of morphological characters.

Females of the Cryptobranchoidea have no spermathecae, and the male cloaca of these forms is devoid of papillae. All the observations on their breeding (Dybowsky 1870 on *Hynobius keyserlingii*, Kunitomo 1910 on *Hynobius nebulosus*, Kerbert 1904 on *Megalo-*

batrachus japonicus, and Smith 1907 on *Cryptobranchus alleganiensis)* indicate external fertilization.*

It is therefore extremely probable that the primitive method of external fertilization characterizes the Cryptobranchoidea, and that the more specialized method of internal fertilization by means of cloacal papillae, spermatophores, and spermathecae, characterizes the Salamandroidea.

The eggs of salamanders are of two general types. Those laid by the most primitive members of both superfamilies (Hynobiidae, Ambystomidae, *Triturus* group of Salamandridae) are pigmented, and with small vitellus. They are usually abandoned in the water, and are presumably the primitive type of salamander egg.

More advanced members of both superfamilies lay non-pigmented eggs with large vitellus, the larvae or young issuing in a more advanced condition (Cryptobranchidae, Plethodontidae).

Such eggs are usually cared for by the parent, male in Cryptobranchidae, female in Plethodontidae, and are frequently laid on land in the case of members of the latter family.

A development from this second type of egg is the production of live young by *Salamandra* in the Salamandridae, and by *Hydromantes* (= *Geotriton* auct.) and by *Oedipus* in the Plethodontidae.

I have recently examined adults of *Amphiuma tridactylum* from Louisiana. The male has the cloaca lined with conspicuous papillae. Under the middorsal wall of the female cloaca lies a non-pigmented mass of tubules. These constitute the spermatheca, and were found upon microscopical examination to be packed with spermatozoa. *Amphiuma* eggs have been long known to be of the second type, and to be guarded by the female. Fertilization is obviously of the Salamandroid type. Anatomically *Amphiuma* shows close resemblance to the Salamandridae in the skull, and to the Plethodontidae in the otic apparatus. These similarities, in connection with the similar breeding habits, indicate that this degenerate type has relationships with the Salamandroidea rather than with the Cryptobranchoidea. Among the former it is allied to the two families aforementioned,

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*I am well aware that Boulenger (1910, p. 49) ascribes to *Hynobius keyserlingii* internal fertilization, amplexus, and non-pigmented eggs with large vitellus. I can find no published evidence supporting this statement, while the observations of Dybowsky (1870), of Shitkov (1895), of Tago (1907), and of Kunitomo (1910) contradict all of these points, and make it clear that *Hynobius* has external fertilization, no amplexus, and pigmented eggs with small vitellus.

and may be, as the Plethodontidae unquestionably are, an American derivative of primitive Salamandrids.

Necturus and *Proteus* both have cloacal papillae, and spermathecae, and the fertilization is internal. *Necturus* lays non-pigmented eggs with large vitellus which are abandoned in the water. *Proteus* ordinarily produces live young, but under certain conditions it lays non-pigmented eggs with large vitellus. Obviously here the breeding habits suggest a Salamandroid ancestry, as do the very few other comparable traits.

No accounts of the breeding habits of *Siren* or of *Pseudobranchus* have ever been published. I was enabled through the kindness of Dr. Stejneger to examine two large adults of *Siren* from North Carolina. A sexual difference appears in the tail, that of the male being longer and with a broader caudal fin:

U. S. N. M. No. 8349: Total length 28 inches; tail 9 inches; tail width 2¾ inches; male.

U. S. N. M. No. 12593: Total length 25 inches; tail 6½ inches; tail width 1½ inches; female.

There is no external difference in the cloaca, which is lined with folded epithelium. No papillae are present in either male or female. The ovaries of the female were full of small, pigmented eggs. Similar eggs, in a gelatinous matrix, filled the lower ends of the oviducts. The openings of the oviducts projected some distance into the cloaca. No trace of spermathecae were found nor could spermatozoa be discovered by repeated search in the cloaca, or in the oviduct. The conclusion seems to be that in all probability *Siren* has external fertilization, and lays small, pigmented eggs. Thus its breeding habits are apparently those of *Hynobius*, and extremely primitive.

The families *Proteidae*, *Amphiumidae*, *Salamandridae*, *Plethodontidae*, and *Ambystomidae* all have the same method of fertilization, which is such a unique one that it could scarcely have been evolved twice. These forms are therefore probably of common origin. The *Hynobiidae*, *Cryptobranchidae*, and *Sirenidae* on the other hand apparently practise external fertilization, a primitive method which does not imply close relationship between the forms practising it.

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DRIFTING DOWN THE MISSISSIPPI

ALFRED C. WEED

Mr. Weed showed a few pictures taken on his recent trip by rowboat from Grafton, Illinois, to Maeys, Illinois, for the collection and study of the fishes of this part of the Mississippi.

THE DISTRIBUTION OF LOWER CALIFORNIAN REPTILES

KARL P. SCHMIDT

(No Abstract)

ECONOMIC INVESTIGATIONS OF SALT WATER FISH IN TEXAS

GEORGE FINLAY SIMMONS

(No Abstract)

THE DISTRIBUTION OF FISHES IN WESTERN SOUTH AMERICA

C. H. EIGENMANN

(No Abstract)

A FLYING FISH FROM BOLIVIA

N. E. PEARSON

(No Abstract)

EXHIBITION OF INTERESTING FROGS AND SNAKES

ALFRED C. WEED

Living specimens of recently described frogs from Minnesota were shown. These frogs, which are related to *Rana pipiens*, have been given the names *Rana burnsi* and *Rana kandiyohi* but their relationships are not known and can not be determined without a considerable amount of further work.

Two Garter Snakes, one of which seems to be the form called *Thamnophis sirtalis parietalis* by Ruthven, were shown. This specimen was taken in central Illinois. A specimen from western Indiana showed much more red along the side than is often found in typical specimens of *sirtalis*.

COLLECTING REPTILES IN DARIEN

THOMAS BARBOUR
(Read by Title, No Abstract)

THE AMPHIBIANS AND REPTILES OF THE SANTA MARTA REGION OF COLOMBIA

ALEXANDER G. RUTHVEN
(Read by Title, No Abstract)

THE CREEK FISH OF WESTERN NEW YORK

T. L. HANKINSON

About three weeks in all were spent by me in studying afield the fish of small streams, locally called brooks or creeks, in the western part of New York state during the summers of 1920 and 1921. Collections were made with minnow seines and data of ecological and economic interest were obtained from all sources. The work was done through the Roosevelt Wild Life Forest Experiment Station of the New York State College of Forestry in cooperation with the Buffalo Society of Natural Sciences, The Erie County Association for the Protection of Birds, Fish and Game, and other local associations. A detailed report, with lists of fish of each stream visited and with planting recommendations, was published in Volume 1 of The Grouse, Buffalo, N. Y. This paper gives a summary of notes, principally on the occurrence of species, in the form of an annotated list.

STREAMS EXAMINED

Lake Ontario drainage

Twelvemile Creek	Wilson Creek

Lake Erie drainage

Tonawanda Creek	Eighteenmile Creek
Ellicott Creek	Big Sister Creek
Ledge Creek	Delaware Creek
Murder Creek	Catarraugus Creek
Ransom Creek	Mortons Corners Brook

Cayuga Creek	Springville Brook
Smoke Creek	Sardinia Brook
Cazenovia Creek	Spooner Brook
Buffalo Creek	Job King Creek
	Trout Brook

Ohio River drainage

Allegheny River	Redhouse Creek
Quaker Run	Little Valley Creek
Wolf Run	Great Valley Creek

ANNOTATED LIST OF SPECIES

1. *Salmo irideus shasta* (Jordan)?—Planted in a number of streams but apparently not thriving. Dr. W. C. Kendall writes of the probability of this being *Salmo shasta* and of the possibility of *Salmo irideus* (Gibbons) being present here also.

2. *Salmo fario* Linnaeus.—Planted in many streams. Not found abundant anywhere. Young were often in headwaters of streams. Two very large ones were caught in Big Sister Creek in the Lake Erie drainage. Largest of these weighed 6½ pounds and was 25 inches long. Found also in the Ohio drainage.

3. *Salvelinus fontinalis* (Mitchill).—Extensively planted in brooks of western New York. The young were numerous in many streams. Only a few creeks had the species in sufficient numbers and of proper size for good trout fishing.

4. *Cyprinus carpio* Linnaeus.—Found in very few creeks in summer. Lake Erie and Lake Ontario drainage.

5. *Campostoma anomalum* (Rafinesque).—Abundant in many creeks in Lake Erie and Ohio drainage.

6. *Chrosomus erythrogaster*. Rafinesque.—Found by us only in Big Sister Creek of the Lake Erie drainage.

7. *Pimephales promelas* Rafinesque.—Found only in a few streams and usually abundant in them. Lake Erie and Lake Ontario drainage.

8. *Pimephales notatus* Rafinesque.—Abundant and very generally distributed in nearly all streams fished. In all three drainage systems.

9. *Semotilus atromaculatus* (Mitchill).—Abundant in each main drainage area in nearly all streams fished.

10. *Richardsonius margarita* (Cope)?—A fish closely resembling this species very numerous in some streams in some Cattaraugus

tributaries and in Quaker Run. Specimens were sent to Mr. H. W. Fowler for comparison with types, and he found the fish was not typical *margarita*. Possibly it should not be assigned to this species, but it appears nearer this form than to any other described species.

11. *Richardsonius vandoisulus* Valenciennes.—A fish that answers the description of this species closely taken from Great Valley Creek.

12. *Richardsonius elongatus* (Kirtland).—Very numerous in many streams of the Lake Erie and Ohio drainage. Common in deep, clear pools of trout brooks.

13. *Notemigonus crysoleucas* (Mitchill).—Apparently a scarce creek fish in the region. A few from Twelvemile Creek and a few from Eighteenmile Creek.

14. *Notropis cayuga* Meek.—In Twelvemile and Tonawanda Creek and much restricted in distribution and habitat in them.

15. *Notropis blennius* Girard.—Very abundant in the Cattaraugus Creek and fairly so in a number of others. In all three main drainage basins.

16. *Notropis whipplii* Girard.—Apparently scarce. Only one found and this in Twelvemile Creek.

17. *Notropis cornutus* (Mitchill).—Very abundant in all open creeks where there were pools of clear water. Spawning activities noted in Cazenovia Creek, June 1, 1920.

18. *Notropis atherinoides* Rafinesque.—Found abundant in places in each of three main drainage basins, but it seemed to be limited to the lower, quieter waters of the streams.

19. *Notropis rubrifrons* Cope.—Found in a few streams of Lake Erie drainage. Males, highly colored in breeding dress and with pearl organs, found in Cazenovia Creek, June 1, 1920.

20. *Rhinichthys cataractae* (Valenciennes).—Present in nearly all areas of swift, shallow riffles where collecting was done. Breeding males with pearl organs over most of the body and on pectoral rays found in Cazenovia Creek, June 1, 1920.

21. *Rhinichthys atronasus* (Mitchill).—Very abundant, and found living under a great variety of conditions. In Lake Erie and Ohio drainage.

22. *Hybopsis amblops* (Rafinesque).—In a few creeks of the Lake Erie drainage.

23. *Hybopsis kentuckiensis* (Rafinesque).—Abundant in creeks of Lake Erie and Ohio drainage. Their nests or stone piles were abundant in Cazenovia Creek, in June, 1920.

24. *Couesius plumbeus* (Agassiz).—Two specimens from Cattaraugus Creek. The scales before the dorsal, 48 instead of 60 as in typical forms. Dr. W. C. Kendall informs me he has found such a range of scale variation.
25. *Exoglossum maxillingua* (LeSueur).—Found by us only in streams of the Allegheny State Park and in the Allegheny River.
26. *Catostomus commersonii* (Lacépède).—Young very abundant in nearly all streams visited and in all three main drainage basins.
27. *Hypentelium nigricans* (LeSueur).—Found almost everywhere in streams, where there were large areas of shallow water with stony bottom. In such a place in Tonawanda Creek a school of hundreds of young ones some 2-2½ inches long noted.
28. *Moxostoma aureolum* (LeSueur).—Found abundant in a pool in Cayuga Creek; also a few in Tonawanda Creek.
30. *Ameiurus nebulosus* (LeSueur).—Found only in Twelvemile and Tonawanda Creeks and in a cut-off pool of Cazenovia Creek. Probably more abundant than our collections show, since we could not seine easily the kinds of places most frequented by this species in streams, which are deep pools with brush or other debris.
31. *Ameiurus natalis* (LeSueur).—Only one taken by us; this from Trout Brook of the Lake Erie drainage.
32. *Schilbeodes gyrinus* (Mitchill).—Found in Twelvemile Creek and in Ellicott Creek.
33. *Noturus flavus* Rafinesque.—Found by us only in Cayuga Creek near Lancaster. Probably more abundant than collections show, since they are difficult to collect with a seine.
34. *Umbra limi* (Kirtland).—Two taken, one in Lake Erie and one in Lake Ontario drainage. Scarcity may be apparent, due to our collecting very little in swampy areas and to the difficulty of taking this species with seines.
35. *Esox vermiculatus* LeSueur.—Several taken in Trout Brook.
36. *Esox lucius* Linnaeus.—Taken only in Twelvemile and in Ledge Creeks.
37. *Eucalia inconstans* (Kirtland).—Abundant only in one stream visited. This a small shallow creek with abundant stonewort growth, in the Cattaraugus system. A few found in other streams of the Lake Erie and Ohio drainage.
38. *Gasterosteus bispinosus* (Walbaum).—Three specimens taken in an alga-filled pool of Wilson Creek of the Lake Ontario drainage.
39. *Pomoxis annularis* Rafinesque.—Two taken in the inlet of a

small lake, which is a part of the Smoke Creek system. Local testimony gave evidence that the species had been planted in this lake.

40. *Pomoxis sparoides* (Lacépède.)—One taken in Twelvemile Creek.

41. *Ambloplites rupestris* (Rafinesque).—Abundant in Tonawanda Creek, and a few found in Cayuga and Cazenovia Creeks. Probably more abundant than record shows, since the species is difficult to seine on account of lying about rocks.

42. *Lepomis gibbosus* (Linnaeus).—Found only in three streams: Twelvemile and Tonawanda Creeks and in the Smoke Creek system.

43. *Micropterus dolomieu* Lacépède.—Common in Tonawanda Creek, both young and adults. Plantings of the species have been made here. Abundant also in Redhouse Creek and in a few other streams.

44. *Percina caprodes zebra* (Agassiz).—Abundant in Eighteenmile and in Twelvemile Creeks in June. A few found in other streams fished in late summer. They appear to be abundant only during breeding migrations from the Great Lakes in early summer or late spring; and they confine themselves chiefly to the lower waters of these streams.

45. *Hadropterus aspro* (Jordan).—A few taken in each of several creeks of the Lake Erie and Ohio drainage.

46. *Boleosoma nigrum* (Rafinesque).—Very numerous in many parts of creeks of Lake Erie and Ohio drainage.

47. *Boleosoma olmstedi* (Storer).—Four taken in Twelvemile Creek of the Lake Ontario system.

48. *Poecilichthys coeruleus* (Storer).—Abundant in Lake Erie and in the Ohio drainage.

49. *Poecilichthys iowae* Jordan and Meek.—A few taken in Twelvemile Creek and in Cazenovia Creek. Apparently scarce.

50. *Etheostoma blennioides* Rafinesque.—A few taken in the Lake Erie and in the Ohio drainage streams.

51. *Catonotus flabellaris* Rafinesque.—Abundant in the Tonawanda Creek system and a few taken in other streams of the Lake Erie and Ohio drainage.

52. *Cottus meridionalis Girard.*—Abundant in two streams, headwaters of the Cazenovia and of the Cattaraugas systems. A few in Little Valley Creek of the Ohio drainage.

53. *Aplodinotus grunniens* Rafinesque.—A large specimen was

seen, which had been caught by a fisherman at the mouth of Wilson Creek.

THE SALIENTIA OF THE OKEFINOKEE SWAMP, GEORGIA

A. H. WRIGHT

During the summers of 1921 and 1922, we studied seventeen species of Salientia in the Okefinokee Swamp, Georgia, or in the outskirts. The research was supported by a grant from the Heckscher Foundation for the Advancement of Research, established by August Heckscher at Cornell University.

In 1921, we found eleven species on Billy's Island, in the heart of the swamp. The other six species prefer entirely or in part the outside. They are *Rana aesopus, Scaphiopus holbrookii, Hyla squirella, Hyla versicolor, Pseudacris nigrita,* and *Rana virgatipes,* the last species also, to a certain extent, within the swamp.

From April 15th or earlier to September 1st, six forms breed. *Pseudacris nigrita* lays in early spring, *Acris gryllus* deposits single submerged eggs, and *Scaphiopus holbrookii* lays bands of eggs which soon become cylinders. *Bufo fowleri,* not in the swamp area, lays files with no inner tube and eggs crowded close, while *Bufo terrestris* has no inner tube but eggs are not crowded nor in double files. *Rana sphenocephala* has a plinth like that of *Rana pipiens.*

From May 15th on to June 1st, five more start. *Pseudacris ocularis* emits single eggs on the bottoms of ponds and on vegetation. *Hyla femoralis* lays large loose pockets on the surface. *Hyla cinerea* deposits a film on water-lily pads and on other surface leaves. *Gastrophryne carolinensis* spawns clear marble-like eggs in films on the surface, these eggs truncated on the top. And *Rana grylio* has large films one by two and a half feet across, much as does *Rana catesbeiana.*

From June 1st to 10th, three species begin. *Bufo quercicus* lays its short bars of eggs on the bottom of ponds. *Hyla squirella* chooses the bottom for its singly-laid eggs as does *Hyla gratiosa.*

From June 20th on, two more appear. *Rana virgatipes* lays a plinth attached to sticks or stems like *R. pipiens* masses, but the individual eggs have no inner envelopes. *Rana aesopus* we found breeding in mid-August, but we suspect it also breeds much earlier.

AN ECOLOGICAL STUDY OF THE COLD BLOODED VERTEBRATES OF SOUTHEASTERN LOUISIANA

PERCY VIOSCA, JR.

Perhaps there are few if any sections of its size in the world that present such a diversity of surface conditions as the state of Louisiana. Although the elevations do not vary greatly, the highest point being perhaps 200 feet above sea level, they are sufficient to produce such diverse types of conditions, that the fauna, although largely Austroriparian, is supplemented by genera and species belonging to each of the adjoining faunal regions.

Because my more intensive studies have been confined largely to the southeastern section of the state, I will confine my remarks to that area bounded on the north by the Mississippi state line, on the east by the Pearl River, and on the southeast and south by the Gulf of Mexico and on the west by the Atchafalaya River. This block of territory comprises some 21 parishes, and includes in its area fifteen more or less important lakes and bays and their tributaries. It is bisected by the lower Mississippi River which runs diagonally across from northwest to southeast. Of the various geologic types of country found throughout the state, only one of importance, the prairie country of southwest Louisiana, is not represented in this area.

As reflected in the character of its flora and fauna, there are not less than fifteen distinct types of environment to consider. These often present sharp contrasts, yet in some instances the merging is so gradual that it is difficult to set a boundary line. The presence of various types of streams further complicates the nature of the surface, so that within certain limits there may be infinite variation. In addition we have a humid atmosphere and subtropical climate, and the absence of extremes of temperature permits a meeting of northern and tropical forms.

All lands in southeastern Louisiana west of the Mississippi, and those on the east side with the exception of that block comprising the so-called Florida Parishes, are of alluvial origin, and I will designate them by the term lowlands. They vary in elevation from the lake and swamp bottoms which are below sea level near the coast, to the alluvial formations near Baton Rouge, which are in the neighborhood of 40 feet above sea level.

THE UPLANDS

For the Florida Parishes I will use the general term uplands, which consist of flat, rolling, and hilly country, varying in elevation from about 8 to 200 feet above sea level. The uplands can be divided into four primary subdivisions.

Division 1. Pine and Hardwood Uplands.

This type of environment, also called the Shortleaf Pine Hills, is represented in the territory under consideration, only in East Feliciana Parish. The woods are generally mixed stands of shortleaf and loblolly pine, sweet gum, hickory, dogwood, and several oaks. The soil is dry and the country cut by deep ravines with cool and often swift creeks. Neither the terrestrial nor aquatic environment here is capable of supporting an extensive fauna, and special adaptations are required. Of the terrestrial species, lizards and certain snakes predominate, and the fauna in general is one which does not depend on an abundance of water for a livelihood. *Hyla versicolor* is the characteristic tree frog, while *Acris gryllus* abounds along the creeks.

Division 2. Hardwood Uplands or Bluff Lands.

To the south and west of the Shortleaf Pine Hills is a strip of territory characterized by a large variety of hardwoods, but only rarely pine. The fauna of this region is essentially like that of the preceding except in the lower levels where, due to the slower run off, there is a greater abundance of water. Furthermore, the bluff lands are bordered on the west by the Mississippi lowlands and are penetrated by the Amite River system with its strip of bottom lands, which are characterized by a more diversified fauna. What we have here is a modified fauna of the various lowland types over a more or less extensive area, in the midst of the higher districts, these being associated with upland species which in some instances are more abundant than they would otherwise be, were not the lowlands present.

Division 3. Longleaf Pine Hills.

To the east of the shortleaf pine area are the Longleaf Pine Hills with gentle slopes, and intertwined by winding creeks. Here we have a limited representation of practically all species found in the uplands generally and in addition, some species which may be said to be characteristic. *Hyla femoralis* is the typical treefrog of this section. In the fine shady creeks and small river bottoms with loose

sandy banks, there is even a great diversity of amphibious creatures. *Amphiuma means, Triturus viridescens,* various *Ambystoma,* and other salamanders being notable among them.

Division 4. Longleaf Pine Flats.

Abruptly bordering the pine hills on the south, lies this strip of flat lands characterized by a beautiful stand of longleaf pine interspersed with loblolly. The streams here, because of the lower elevation, are normally sluggish and often spread out over low areas, forming swampy situations. These are characterized by swamp magnolia in the shallower areas and tupelo in the more permanent swamps. The extent and diversity of these semiaquatic situations, and the more sluggish character of the streams, permits of a great diversity of living forms which is particularly well reflected in the character and nature of its cold blooded vertebrates. There is a remarkable mixed association of upland and swamp-loving species and it is here that Louisiana finds its greatest wealth of reptile and amphibian life. At least 90% of the species found within the borders of our state have already been found in this very limited area. Typically the country is north Floridian, rather than Louisianian, and several southeastern species, not found elsewhere in our state, have congenial habitats here. *Bufo quercicus, Bufo terrestris,* and *Hyla gratiosa* are significant examples. The situation may be further complicated where the pine flat region is abruptly bordered by a river valley or brackish marsh.

With the fish also, we find in this section, a large mixed association of species in great concentration, those belonging to the cool upland streams being found side by side with those of still or warmer waters.

THE LOWLANDS

The remaining lands of Southeast Louisiana, the alluvial areas or lowlands, are by no means uniform and can also be divided into several distinct faunal divisions.

Division 5. Alluvial Ridges.

Those strips of alluvial lands which border the present or former beds of the Mississippi, forming parallel ridges, are more elevated than the remaining lowlands and live oaks draped with Spanish moss are the characteristic trees. The most important of these ridges are those which border the present river and along Bayou Lafourche. In addition there are many branches of these ridges

which spread out in fan-shaped formation and represent former deltas of the Mississippi.

The fauna of these ridges differs least from that of the uplands and there are many species in common. Some forms, such as *Hyla squirella,* and *Elaphe obsoleta confinis,* are typical. Other forms associated with this environment are the spotted king snake *(Lampropeltis getulus holbrooki),* the blue racer *(Coluber constrictor flaviventris),* and the lizard *(Anolis carolinensis),* which find their most congenial habitats here and are often found in incredible numbers. Water snakes and turtles are numerous as species and as individuals, but these are determined largely by the various adjoining aquatic environments. Salamanders on the other hand are unknown.

The fish are largely warmer water species belonging to the Mississippi system, with some typical southern species such as *Gambusia affinis* added.

An interesting modification of the alluvial ridges is presented by the so-called "chenieres" of the gulf region, where the land is low and slopes away into the salt marshes. Where the land is subject to periodic overflow, the large oaks of the higher ridges are replaced by the water oaks, and the fauna differs in having a more restricted terrestrial and fresh water society.

Division 6. Wooded Alluvial Swamp Lands.

The alluvial ridges, due to their mode of formation, have their highest elevations next to the river beds which they parallel, and they gradually slope away on either side until their height is below that of the average yearly ground water level. Here the oaks and other dry land vegetation cease, and, except near the Gulf coast, we have varying widths of densely wooded swamps which are in many respects different from the lower areas or brakes in the uplands. The important woods of these swamps are cypress and tupelo, and in some instances willow.

Here we find an interesting society of amphibious animals, *Rana catesbeiana, Chelydra serpentina,* and *Kinosternon subrubrum hippocrepis,* predominating. Almost peculiar to this environment is *Amphiuma tridactylum* which lives largely in the network of subterranean chambers and passages made by the red swamp crayfish, *Cambarus clarkii,* upon which it feeds. Associated with this species of *Amphiuma,* and as far as has been determined, feeding exclusively

upon it in this region, is the horn snake, *Farancia abacura*. Other species such as the alligator, *Agkistrodon piscivorus, Natrix sipedon fasciata,* and *Pseudemys elegans,* which are common to the lowlands generally, are particularly abundant in this environment. *Amiatus calva* and *Mollienisia latipinna* and several sunfishes are characteristic among the fishes.

Division 7. Fresh Water Marshes.

Adjacent to the wooded swamps on the side away from the ridge lands, and following their general course, are varying widths of marsh lands. Those farthest from the sea are supplied by rainwater, and fresh water grasses, flags, rushes, and lotus are the characteristic vegetation, the last named being found in the more open areas or lagoons.

The denser areas in these marshes furnish the ideal habitat for *Hyla cinerea* and *Rana sphenocephala,* while in the more open areas, *Rana catesbeiana* has been replaced by the most aquatic frog on this continent, *Rana grylio,* a species intimately associated with our native lotus. *Acris crepitans,* although a lowland species generally, is especially abundant here, and there is an assortment of water snakes and turtles, of which *Natrix cyclopion* and *Pseudemys troostii* are perhaps the most characteristic.

Division 8. Salt Water Marsh.

Nearer the sea, being frequently bathed by brackish or salt waters due to tides and floods, the nature of the marsh is considerably changed. In fact we have another distinct zone where the chief vegetation is composed of wiry salt marsh grasses. No strict line of demarcation exists to distinguish the salt from the fresh water marshes, the fresh water flora and fauna gradually diminishing as the salt content increases.

Natrix clarkii and *Pseudemys alabamensis* are really the characteristic reptiles of the brackish marsh, while the latter is replaced by *Malaclemys pileata,* the famous Louisiana Diamond Back Terrapin, as we approach the sea. *Rana sphenocephala* and *Rana grylio* can resist a limited amount of salt, but when this becomes noticeable, crabs, fiddlers, molluscs, and fishes capable of withstanding great fluctuations in salinity, replace the strictly fresh water species.

Division 9. Sea Beaches.

As still another zone, we might consider the narrow strip of

coastal islands which often partake of the combined nature of sea beach, alluvial ridge, and salt marsh. Being built up by the waves and winds upon an alluvial substratum, the soil of these islands is composed largely of fine sand, in reality made up of the remains of innumerable marine molluscs pulverized by the pounding of the surf.

The flora of the sea beach consists mostly of trailing vines and sand-binding grasses, usually above the average high water. Where the beach connects with some alluvial ridge, oaks, bushes, and other ridge land forms make up the vegetation and the fauna partakes of the nature of the alluvial species *Hyla squirella* and *Gastrophryne carolinensis* sometimes reaching to the very edge of the Gulf. An absence of cold blooded vertebrates, however, is the chief characteristic of these islands, the diamond back terrapin and various sea turtles visiting them largely for egg laying.

AQUATIC ENVIRONMENTS

Concerning the more permanent aquatic environments, we have also a division into several distinct zones, although the lines of demarcation are not as obvious as in the case of the terrestrial and semiaquatic environments.

Division 10. Upland streams.

The upland streams, partly considered already with their associated terrestrial environments, particularly in connection with amphibious creatures, need special mention in regard to truly aquatic forms. These streams vary from small rivers and creeks, often in deep ravines, to shallow winding creeks, and according to local circumstances, may be clear or silt bearing. Their chief characteristics are cool running waters in sandy beds, and an absence of aquatic vegetation. The aquatic vertebrates must be adapted to these conditions and are therefore chiefly species capable of withstanding currents, and of carnivorous habits. *Necturus maculosus* finds a congenial habitat in some of these streams.

Division 11. Silt Bearing Rivers.

In contrast to the smaller upland streams in deep gullies, we have the larger silt bearing rivers which have built their own beds often above the surrounding country and even far out over the gulf bottom. The four of greatest importance in our territory, are: the Pearl, the Amite, the Mississippi, and the Atchafalaya rivers and their delta streams.

The ecological associations of such streams are markedly different from most of the aquatic environments within our area and are in fact characteristic of conditions higher up the Mississippi Valley. There is a wealth of fresh water mussels, which are scarce in our other streams, and the gizzard shad, the fresh water drum, three species of buffalofish, and the paddlefish are characteristic. A great variety of turtles and water snakes is found along their shores, the soft shelled turtles being characteristic. Certain lakes and innumerable ponds are temporary features of these streams and carry the characteristic fauna in far greater concentration than the mother streams.

Division 12. Tide Level Fresh Water Lakes and Bayous.

Because the waters of our larger rivers are higher than the made land which they have deposited on the floor of the gulf, it is obvious that the Louisiana lowlands cannot be drained by these waterways. Nature has therefore installed another drainage system consisting of an intricate network of sluggish bayous which take the lines of least resistance and flow to the most accessible sea level lakes. These lakes are really small arms of the gulf, which the rivers have not completely filled in. They generally appear in a series or chain formation, the various members being connected by wide bayous or passes. The innermost of a series, being natural reservoirs receiving the drainage water from the lowlands, are therefore freshwater lakes.

Characteristic of the reptile life inhabiting these bayous and lakes is the alligator snapping turtle, *Natrix rhombifera,* and the larger members generally of the turtles and snakes of the adjoining swamps and marshes. They are also the haunts of the largest alligators where not molested. Where there is a protective growth of Cabomba or other submerged aquatics, there occurs a form of newt which appears to pass its entire life history without developing any land form. The fishes living here by preference are some of the more generally distributed forms such as the large mouthed black bass, the blue cat and great gar, while others such as certain sunfish are distinctive. This fish fauna is thus derived from two principal sources, the Mississippi valley forms and those belonging to the coastal streams. Certain salt water forms may also be found at some or all seasons of the year.

Division 13. Brackish Water Lakes.

The outermost lakes and bays of a series, being connected directly with the gulf through large passes, and being affected by the daily change of the tides, naturally contain water of a high degree of salinity, while the intervening members of any series contain waters of intermediate densities. They vary considerably with the seasons, and are often affected suddenly by abnormal winds, tides, and rainfall.

Manifesting the presence of salinity in the water, even tho relatively infrequent and low, is the occurrence of acorn barnacles, the small clam, *Rangia cuneata, Spongilla wagneri,* certain crabs, and shrimp. Certain salt water food fishes, notably the croaker, spotted weakfish, redfish, mullet, sheepshead and flounder, are at times associated with fresh water species. Lakes Pontchartrain and Salvador are noteworthy among the larger bodies of water in which the presence of salt water species seems least inimical to truly fresh water forms.

Division 14. Salt Water Lakes.

Approaching the sea, typical salt water lakes and bays are encountered, and here the fresh water forms give way entirely to marine species and we find ideal conditions in these mud bottomed areas for the growth of the oyster, the blue crab, the large edible prawns, the menhaden, and a long list of food fishes.

Division 15. Gulf of Mexico.

We have finally to consider the open Gulf itself, which near the Louisiana coast is usually soft bottomed, being covered by a muddy ooze mixed with particles of fine sand. Although many species are common to both the bays and the open Gulf, conditions are not alike, due perhaps to greater and more uniform salinity, the action of the waves, the greater depth of the water, and the presence of sand.

The Gulf waters of Louisiana differ materially from those of neighboring states, owing to the absence of coarse sand or hard rock bottoms, and to the presence of soft mud and clays of alluvial origin. The water is never absolutely clear and fine sand and silt are always in suspension, consequently sea weeds, hydroids, and bryozoa find it difficult to obtain a foothold. Because of these conditions, the marine fish fauna of Louisiana is very characteristic.

CONCLUSION

Before concluding I wish to emphasize again the fact that this region in which such a great diversity of conditions of existence occurs, is such a relatively small part of this country, and contains in addition to the more significant types of environment, endless possibilities of combination and variation. It is little wonder then that the biologist finds in this section, such a wonderful diversification of living forms; a fertile field for investigation which can hardly be equalled in the temperate world.

Altho these investigations are only in a preliminary stage, many interesting and valuable discoveries have already come to light. Of particular significance are those connected with the zonal distribution and status of certain species. Because of the proximity and accessibility of the various types of conditions, we can often determine just which factors of climatic, meteorologic, or topographic nature, affect or limit the distribution of various species. For example, the humid character of the surface soil over the greater part of the area is the chief factor which restricts the range of *Cnemidophorus sexlineatus* while encouraging the widespread distribution of *Leiolopisma laterale*.

The puzzling status of the Genus *Acris,* as far as Louisiana is concerned has been positively cleared by these studies. There are two distinct species in Louisiana, the upland species being, tentatively, *Acris gryllus,* and that of the lowlands, *Acris crepitans.* Wherever their ranges overlap, they are found side by side without interbreeding, each with its characteristic chorus and habits.

Much the same thing occurs with *Amphiuma,* and where the two habitats merge, *means* of the upland streams is found side by side with *tridactylum* of the lowland swamps.

On the other hand, we have *Coluber constrictor* in the two extremes of its sub-species each in its typical habitat, yet illustrating every possible blending of the two forms in the course of an hour's auto ride, wherever their different environments merge.

This investigation has already extended the known range of a number of species. For instance *Bufo valliceps,* a Mexican toad, is now known as far east as Pearl River, and *Rana grylio* is distributed over the entire southern portion of this state, both following their characteristic environments near the coastal strip. Several new items have been added to Louisiana's check list and at least two

undescribed forms, a new species of tree frog, and a water snake whose status has not yet been determined.

It is therefore my belief, because of the results already obtained, that further investigations of this nature will greatly assist structural studies, in clearing up the more puzzling questions connected with the distribution of life in the Austroriparian and adjoining faunal regions.

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